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US ARMY CORPS
OF ENGINEERS
New England District

Contract No. DACW33-01-D-0004
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APPENDIX G-3

Analysis of Sediment Transport Potential for Four Open Water Disposal Alternatives in Long Island Sound

LONG ISLAND SOUND DREDGED MATERIAL DISPOSAL SITE DESIGNATION ENVIRONMENTAL IMPACT STATEMENT

Final Report

Appendix G-3

Analysis of Sediment Transport Potential at Four Dredged Material Disposal Alternatives in Long Island Sound

Submitted to

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1. INTRODUCTION

While most dredged material released into a designated disposal site will be deposited on the seafloor where it will remain, some may be transported away from the point of release. This can happen in two ways: fine dredged sediment may be carried by local currents while still in the water column immediately after disposal, or they may be deposited on the sea floor and then later resuspended into the water column by occasional high waves and/or strong currents. For the purpose of this EIS, a modeling effort was undertaken to help determine the conditions which may lead to the transport of dredged material released in the WLIS, Bridgeport, Milford, and CLIS alternatives as well as the extent of such transport. The methods and results of that effort are described in this Appendix.

2. WIND ANALYSIS

Historical wind data collected near Long Island Sound were analyzed to determine the region's wind climatology and severity of high-energy storm events for subsequent use in sediment transport modeling. Wind data sets from multiple sources were considered: Brookhaven National Laboratory on Long Island, Groton, CT airport, and Block Island, NY airport and the NOAA offshore C-Man station in Buzzards Bay, Massachusetts. These inland meteorological data are affected by frictional attenuation of wind speeds over land. Wind data collected at the meteorological station in Buzzards Bay were thought more representative of actual wind stress applied to the sea surface of Long Island Sound than the land-based stations. Therefore, wind data from the C-Man station in Buzzards Bay were used to determine extremal winds at various return periods.

NOAA C-Man buoy located in Buzzards Bay, Massachusetts averaged winds over 8 minutes for the time period 1985-1994, 1997-2001 (12 years). These data were observed approximately 82 feet above mean sea level. These data were obtained from NOAA and have passed the agency’s quality control screening.

These extremal results were obtained by separating all observations into directional sectors, each sector 45° wide and centered on the principal compass points: north, northeast, east, southeast, *etc.* For example, north winds were assumed to blow from 337.5° to 22.5°. Wind observations for each sector were ranked by magnitude, with the strongest winds ranked highest. These data were then screened to assure storm events were ranked individually, so that two or more observations from a single severe storm did not bias the rankings. The screening assures analysis was performed on statistically-independent data points.

The peak wind events for each directional sector were input to a Fisher-Tippet (Type I) extremal function to determine wind speeds from each direction at return periods ranging from 1 to 100 years. Results of this analysis are presented in Table 1.

Table 1. Extreme Wind Speeds (knots) Reported from each Direction at Various Return Periods

Return Period (years)	North	NE	East	SE	South	SE	West	NW
1	39.8	41.1	40.3	40.6	40.5	42.4	41.3	38.1
2	42.8	44.6	44.3	44.1	43.4	45.2	43.8	40.3
5	46.7	49.1	49.4	48.7	47.1	48.8	47.1	43.2
10	49.6	52.5	53.2	52.2	50.0	51.5	49.5	45.3
20	52.6	55.9	57.0	55.6	52.8	54.2	52.0	47.4
50	56.4	60.4	62.1	60.2	56.5	57.8	55.2	50.2
100	59.4	63.8	65.9	63.6	59.3	60.5	57.6	52.4

Wind data from all four stations are presented in rose diagrams (Figure 1). The annulus radii represent the frequency of occurrence (dotted radial lines are labeled 5%, 10%, 15% and 20% occurrence), and shading indicates the magnitude of the wind speed. For example, the Buzzards Bay site shows that winds were from the southwest about 13% of the time; about 8% of winds were SW between 10 and 15 knots, and about 4% of winds were between 15 and 20 knots.

In general, observed wind speeds were typically less than 40 knots (Figure 1). Longer records show clear seasonal variability; stronger winds prevailed in winter and milder winds during summer. Statistical analysis showed that winds had a strong westward component about 32% of the time. West wind events with speeds exceeding 30 knots were sustained for three-to-five days, persisting typically for longer periods of time than wind events from other directions. Although northeast (extratropical) storms have been noted to produce significant sediment transport on the U.S. Atlantic coast, LIS is fetch-limited to the northeast and therefore somewhat immune from the devastating effects such storms can leave. Hurricanes have produced the strongest wind speeds on record (Gloria in1985; Bob in 1991); however the rapid change in wind direction during these events (due to the swift passage of the low pressure eyes) appears to limit hurricane's impact on bottom currents and resulting sediment transport.

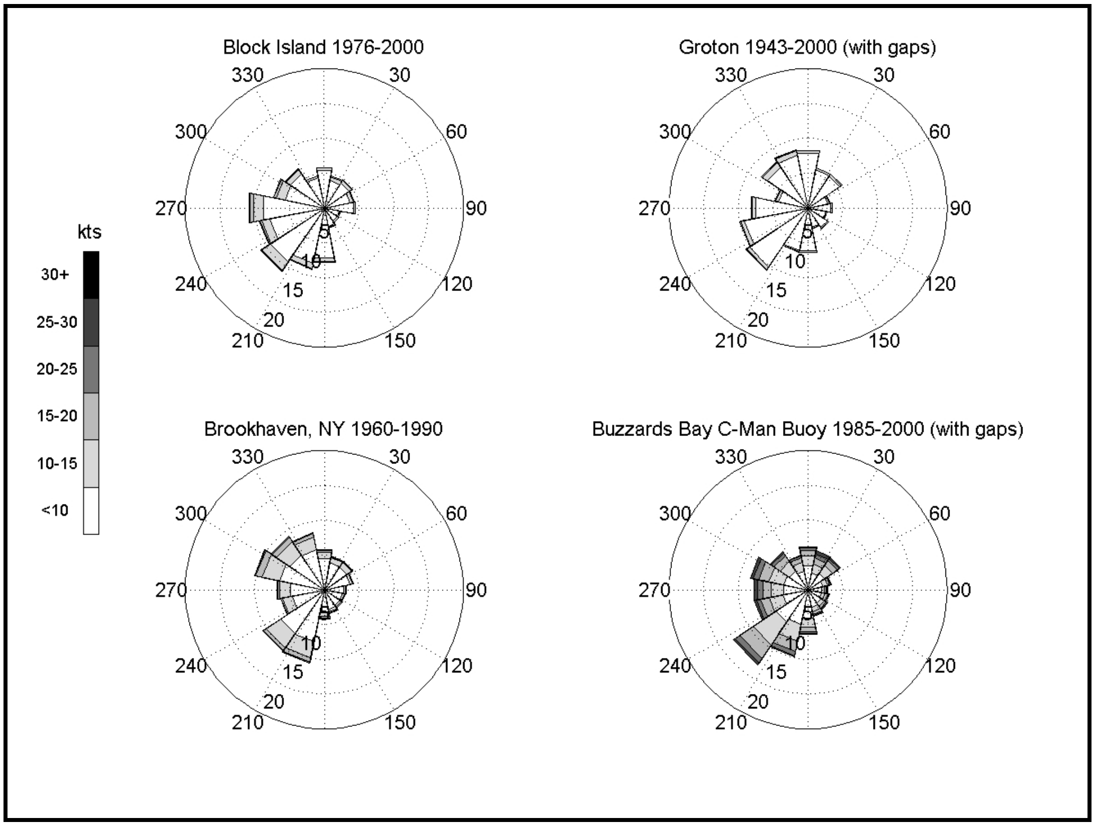

Figure 1. Rose Diagrams Depicting Wind Observations from Block Island, Groton, Brookhaven, and Buzzards Bay Meteorological Stations.

3. WAVE MODELING

The calculation of wave heights and periods for the four disposal site locations was accomplished using the Windspeed Adjustment and Wave Growth module of the USACE Automated Coastal Engineering System (ACES) numerical model. The model is well suited for the evaluation of waves on Long Island Sound, since it is formulated to calculate wave growth over restricted fetches in shallow water conditions, which allows for a specific evaluation of waves at each site.

The initial step was to measure fetch distances for each site on 45-degree spacings over the entire compass, (see Table 2 for fetch distances). These data were entered into the model along with the return period wind speeds and directions. Then the wind speeds were normalized for height of measurement, observation duration, wind duration, and observation type for input into wave generation equations. Based on the adjusted wind data the ACES model computes wave height and period based on the Bretschneider-Reid equations, which results in the output of zero moment wave height (H_{mo}) and peak period (T_p) for each return period wind speed and direction for each of the disposal sites. The equations are based on an average depth over the fetch and interpolated averaged fetch length.

Table 2. Fetch Distances for Long Island Sound Disposal Sites

Site	Fetch Distance (miles)									
	N 0	**NE 45**	**E 90**	**SE 135**	**S 180**	**SW 225**	**W 270**	**NW 315**	**ENE 67.5**	**WSW 247.5**
WLIS	3.3	19.7	46.9	4.77	3.3	10.1	9.7	4.7	77.4	20.8
Bridgeport	5.5	19.97	40	10.3	11.3	12.7	10.2	4.1	62.2	35.6
Milford	5.9	17.5	34.8	19.3	10.9	20.4	14.8	4.5	52.9	42.7
CLIS	6.5	10.7	30.2	17.1	12.8	15.7	17.7	7.85	44.8	50.8

The results from the analysis are shown in Table 3 through Table 6. There is one table for each disposal site, and each table is divided by the wind return period and direction. Easterly winds directed along the axis of Long Island Sound generate the largest wave heights and periods. This is a result of the large fetch distances to the east-northeast along the axis of the sound. West-southwest winds also generate large waves due to the fetch distance along the sound axis, especially for the Milford (Table 5) and CLIS (Table 6) sites, since they are located further to the east. Comparison of the sensitivity of varying fetch distances and wind speeds on wave growth, reveals that fetch has a more significant impact on wave heights (*i.e.,* at any given wind speed the ultimate wave growth is limited by fetch distance).

Table 3. Computed Wave Heights for Western Long Island Sound (WLIS) Disposal Site

	Wind Direction (from)																							
	0			45			90			135			180			225			270			315		
Return Period (years)	Wave Height-Hmo (ft)	Peak Wave Period (sec)	Mean Wave Direction	Wave Height (ft)	Wave Period (sec)	Mean Wave Direction	Wave Height (ft)	Wave Period (sec)	Mean Wave Direction	Wave Height (ft)	Wave Period (sec)	Mean Wave Direction	Wave Height (ft)	Wave Period (sec)	Mean Wave Direction	Wave Height (ft)	Wave Period (sec)	Mean Wave Direction	Wave Height (ft)	Wave Period (sec)	Mean Wave Direction	Wave Height (ft)	Wave Period (sec)	Mean Wave Direction
1	4.64	4.17	39	7.19	5.27	75	8.39	5.72	89	6.68	5.09	97	3.17	3.50	119	4.96	4.22	230	4.15	3.89	265	3.03	3.35	287
2	5.06	4.34	39	7.86	5.50	75	9.25	6.01	89	7.33	5.33	97	3.45	3.65	119	5.35	4.37	230	4.46	4.02	265	3.24	3.45	287
5	5.61	4.56	39	8.73	5.80	75	10.35	6.36	89	8.17	5.62	97	3.82	3.83	119	5.87	4.55	230	4.86	4.18	265	3.52	3.58	287
10	6.03	4.71	39	9.38	6.01	75	11.17	6.62	89	8.80	5.83	97	4.11	3.96	119	6.26	4.69	230	5.17	4.29	265	3.74	3.68	287
20	6.45	4.86	39	10.03	6.21	75	11.97	6.87	89	9.42	6.04	97	4.40	4.09	119	6.66	4.82	230	5.48	4.41	265	3.96	3.78	287
50	7.02	5.06	39	10.87	6.47	75	13.02	7.18	89	10.24	6.30	97	4.78	4.25	119	7.20	5.00	230	5.89	4.56	265	4.25	3.90	287
100	7.45	5.20	39	11.50	6.66	75	13.79	7.40	89	10.85	6.49	97	5.07	4.37	119	7.60	5.12	230	6.21	4.66	265	4.47	3.99	287

Table 4. Computed Wave Heights for Bridgeport Disposal Site

	Wind Direction (from)																							
	0			45			90			135			180			225			270			315		
Return Period (years)	Wave Height-Hmo (ft)	Peak Wave Period (sec)	Mean Wave Direction	Wave Height (ft)	Wave Period (sec)	Mean Wave Direction	Wave Height (ft)	Wave Period (sec)	Mean Wave Direction	Wave Height (ft)	Wave Period (sec)	Mean Wave Direction	Wave Height (ft)	Wave Period (sec)	Mean Wave Direction	Wave Height (ft)	Wave Period (sec)	Mean Wave Direction	Wave Height (ft)	Wave Period (sec)	Mean Wave Direction	Wave Height (ft)	Wave Period (sec)	Mean Wave Direction
1	4.78	4.23	35	6.94	5.15	72	7.99	5.55	89	6.43	4.97	99	4.97	4.24	185	5.49	4.46	224	4.90	4.21	259	3.03	3.35	284
2	5.21	4.40	35	7.60	5.38	72	8.82	5.83	89	7.07	5.20	99	5.40	4.41	185	5.92	4.61	224	5.25	4.35	259	3.24	3.46	284
5	5.78	4.61	35	8.46	5.66	72	9.90	6.18	89	7.89	5.49	99	5.96	4.61	185	6.48	4.81	224	5.73	4.52	259	3.52	3.59	284
10	6.21	4.77	35	9.10	5.87	72	10.71	6.43	89	8.51	5.70	99	6.39	4.76	185	6.91	4.95	224	6.09	4.64	259	3.74	3.69	284
20	6.65	4.92	35	9.74	6.07	72	11.50	6.67	89	9.13	5.90	99	6.83	4.91	185	7.35	5.09	224	6.45	4.77	259	3.95	3.78	284
50	7.23	5.12	35	10.58	6.33	72	12.53	6.97	89	9.93	6.15	99	7.41	5.09	185	7.92	5.27	224	6.93	4.93	259	4.24	3.91	284
100	7.67	5.26	35	11.20	6.52	72	13.30	7.19	89	10.54	6.34	99	7.85	5.23	185	8.36	5.41	224	7.30	5.05	259	4.47	4.00	284

Table 5. Computed Wave Heights for Milford Disposal Site

	Wind Direction (from)																							
	0			45			90			135			180			225			270			315		
Return Period (years)	Wave Height-Hmo (ft)	Peak Wave Period (sec)	Mean Wave Direction	Wave Height (ft)	Wave Period (sec)	Mean Wave Direction	Wave Height (ft)	Wave Period (sec)	Mean Wave Direction	Wave Height (ft)	Wave Period (sec)	Mean Wave Direction	Wave Height (ft)	Wave Period (sec)	Mean Wave Direction	Wave Height (ft)	Wave Period (sec)	Mean Wave Direction	Wave Height (ft)	Wave Period (sec)	Mean Wave Direction	Wave Height (ft)	Wave Period (sec)	Mean Wave Direction
1	4.58	4.12	33	6.60	5.00	72	7.64	5.40	90	6.62	5.01	111	5.28	4.42	205	6.64	4.95	226	5.81	4.63	255	4.00	3.86	281
2	4.99	4.29	33	7.23	5.22	72	8.46	5.68	90	7.28	5.24	111	5.73	4.59	205	7.14	5.12	226	6.23	4.78	255	4.28	3.98	281
5	5.54	4.50	33	8.06	5.50	72	9.51	6.02	90	8.13	5.52	111	6.32	4.80	205	7.80	5.34	226	6.77	4.96	255	4.65	4.13	281
10	5.96	4.65	33	8.68	5.71	72	10.30	6.26	90	8.78	5.73	111	6.77	4.96	205	8.29	5.50	226	7.18	5.10	255	4.93	4.24	281
20	6.38	4.80	33	9.30	5.90	72	11.09	6.50	90	9.42	5.93	111	7.22	5.11	205	8.79	5.65	226	7.60	5.24	255	5.21	4.35	281
50	6.95	4.99	33	10.12	6.15	72	12.11	6.79	90	10.26	6.19	111	7.82	5.30	205	9.45	5.85	226	8.15	5.41	255	5.59	4.49	281
100	7.38	5.13	33	10.74	6.33	72	12.87	7.01	90	10.89	6.37	111	8.28	5.45	205	9.94	5.99	226	8.56	5.54	255	5.88	4.60	281

Table 6. Computed Wave Heights for Central Long Island Sound (CLIS) Disposal Site

	Wind Direction (from)																							
	0			45			90			135			180			225			270			315		
Return Period (years)	Wave Height-Hmo (ft)	Peak Wave Period (sec)	Mean Wave Direction	Wave Height (ft)	Wave Period (sec)	Mean Wave Direction	Wave Height (ft)	Wave Period (sec)	Mean Wave Direction	Wave Height (ft)	Wave Period (sec)	Mean Wave Direction	Wave Height (ft)	Wave Period (sec)	Mean Wave Direction	Wave Height (ft)	Wave Period (sec)	Mean Wave Direction	Wave Height (ft)	Wave Period (sec)	Mean Wave Direction	Wave Height (ft)	Wave Period (sec)	Mean Wave Direction
1	3.49	3.58	22	5.99	4.75	78	7.25	5.24	91	6.29	4.86	111	5.31	4.41	166	6.05	4.70	231	6.10	4.74	267	4.49	4.09	286
2	3.81	3.73	22	6.57	4.97	78	8.04	5.50	91	6.92	5.09	111	5.76	4.58	166	6.52	4.87	231	6.53	4.89	267	4.80	4.21	286
5	4.24	3.91	22	7.34	5.24	78	9.06	5.83	91	7.74	5.36	111	6.36	4.79	166	7.13	5.07	231	7.10	5.08	267	5.21	4.37	286
10	4.57	4.04	22	7.92	5.43	78	9.83	6.07	91	8.36	5.57	111	6.82	4.95	166	7.59	5.23	231	7.53	5.22	267	5.52	4.49	286
20	4.90	4.17	22	8.50	5.62	78	10.60	6.30	91	8.99	5.76	111	7.28	5.10	166	8.06	5.37	231	7.96	5.36	267	5.83	4.61	286
50	5.35	4.34	22	9.27	5.86	78	11.60	6.59	91	9.81	6.01	111	7.88	5.29	166	8.67	5.56	231	8.53	5.54	267	6.25	4.75	286
100	5.69	4.46	22	9.85	6.04	78	12.35	6.80	91	10.42	6.19	111	8.35	5.43	166	9.14	5.70	231	8.96	5.67	267	6.57	4.86	286